Chapter 17

Phytochemicals and Nutraceuticals of *Moringa oleifera* Lam.: Treating Neurodegenerative Disorders

Varsha Nigam*
Department of Botany, Guru Nanak Khalsa College, Yamuna Nagar, Haryana, India

Abstract

The nutritional value of *Moringa oleifera* Lam. is exceptionally high, with its various parts containing essential vitamins, minerals, and biomolecules. These include vitamin A, thiamin, riboflavin, niacin, vitamin C, calcium, copper, magnesium, phosphorus, zinc, potassium, protein, and carbohydrates. Additionally, the leaves and pods are rich in amino acids such as arginine, histidine, lysine, and tryptophan. As a result, Moringa is a straightforward and accessible solution for addressing malnutrition. Beyond its nutritional benefits, *Moringa oleifera* leaves and seeds extracts exhibit neuroprotective and memory-enhancing properties, making them valuable in combating several neurodegenerative disorders. Key neuroprotective phytochemicals isolated from Moringa oleifera, including quercetin, chlorogenic acid, myricetin, isoquercetin, and cryptochlorogenic acid, have shown efficacy against Alzheimer's disease (AD), Parkinson's disease (PD), amnesia, ischemia-reperfusion injury (IRI), depression, epilepsy, multiple sclerosis (MS), Huntington's disease, cognitive impairment (CI), oxidative stress, and other related conditions. The aim of this study is to provide a comprehensive overview of the phytochemicals, nutritional quality, and applications of *Moringa oleifera* in the context of

* Corresponding Author's Email: varshanigam29@gmail.com.

In: Natural Solutions for Neurodegenerative Disorders
Editors: Rahul Kumar Sharma, Shailesh Sharma, Ajmer Singh Grewal et al.
ISBN: 979-8-89530-231-6
© 2025 Nova Science Publishers, Inc.

neurodegenerative disorders. This will aid in assessing future research opportunities and exploring potential advancements in this area.

Keywords: *Moringa oleifera,* nutraceutical use, phytochemicals, neurodegenerative disorder, antioxidants

Abbreviations

AD	Alzheimer's disease
CI	Cognitive impairment
IRI	Ischemia-reperfusion injury
MS	Multiple sclerosis
PD	Parkinson's disease

Introduction

Moringa oleifera Lam., commonly known as the "wonder tree," belongs to the Moringaceae family and is also known by various names, including its Hindi name, Sahajan. The Moringa tree is native to the tropical regions of Southeast Asia, with India being the world's largest grower of moringa. The tree is also utilized for agricultural and medicinal purposes in the Philippines, Africa, Central America, Indonesia, Pakistan, Nepal, and Taiwan. This study aims to provide current and organized information on the phytochemicals, nutritional value, and therapeutic uses of *Moringa oleifera* to evaluate possibilities for future research and explore its medicinal potential. According to the World Health Organization, 80% of the global population depends on medicinal plants (El-Saadony et al., 2023). Moringa leaves and seeds have been used for thousands of years to treat serious diseases and improve wound healing. Despite their widespread use in food and medicine, the effectiveness of Moringa leaves and other products in treating malnutrition and their therapeutic effects on humans have not been well-documented (Dhakad et al., 2019). The use of different parts of the Moringa tree, such as seeds, leaves, seed oils, gum, bark, roots, and flowers, is extensive in herbal remedies. Moringa leaves are reported to contain antioxidants, including flavonoids, phenolics, and carotenoids, and are noted for their optimal nutritional balance of vitamins, minerals, amino acids, and fatty acids (Abdull Razis et al., 2014; Vongsak et al., 2014). Moringa has been used medicinally for ages and across

numerous cultures worldwide to treat a wide range of ailments, including acne, blood impurities, bronchial inflammation, sinusitis, chest congestion, cholera, fevers, ulcers, convulsions, high cholesterol, kidney problems, and hyperglycemia (Singh et al., 2012; Sharma et al., 2012).

Botanical Description of *Moringa oleifera*

Moringa tree typically grows to a height of 2-8 meters and features grey bark, tripinnately compound leaves, and oval leaflets. At the base of each leaf, where it joins the branch or stem, are swellings called pulvini. The leaves are 20-70 cm long, greenish, and droop when young, with glands present at the base of the petioles. Each leaf bears two pairs of opposing ovate leaflets and one at the apex, all 1-2 cm long. Moringa produces pleasantly fragrant clusters of flowers, each with five white or cream petals, 2.5 cm wide, adorned with yellow dots at the base. The petals encircle five stamens and five staminodes in the androecium, held to one side. The fruits of Moringa plants are capsules, hanging and 22-45 cm long, angled, and dagger-like, which dehisce explosively to release white-brown seeds. Each seed has three papery white wings that facilitate airborne dispersal (Morton, 1991; Raja et al., 2016).

Phytochemicals of *Moringa oleifera*

Numerous bioactive compounds, including flavonoids, tannins, phenolic acids, alkaloids, glucosinolates, and terpenes, are found in *Moringa oleifera*. The diversity of these phytochemicals supports a wide range of pharmacological applications.

Flavonoids

The majority of the flavonoids found in this genus are glycosides and flavanols. Common flavonoids include myricetin, apigenin, rhamnetin, kaempferol, quercetin, and isoquercetin (see Figures 1A and 1B). According to Rani et al., (2018), the high concentration of flavonoids in the Moringa genus is a key factor contributing to its potent antioxidant activity.

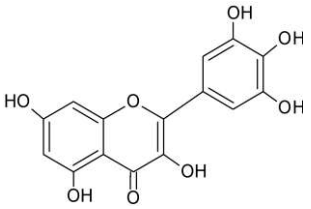

Figure 1A. Structure of myricetin.

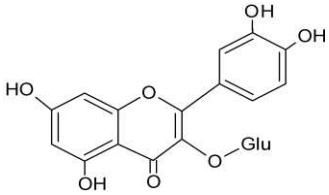

Figure 1B. Structure of isoquercetin.

Phenolic Acids

The main phenolic acids present in *Moringa oleifera* leaves include ferulic acid, ellagic acid, chlorogenic acid, and cryptochlorogenic acid, with gallic acid being the predominant phenolic acid (Vongsak et al., 2014; Leone et al., 2015) (Figure 2A, 2B).

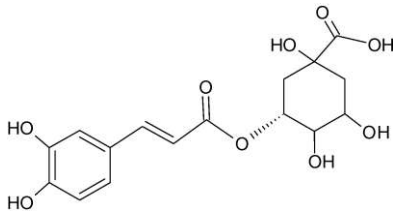

Figure 2A. Structure of chlorogenic acid.

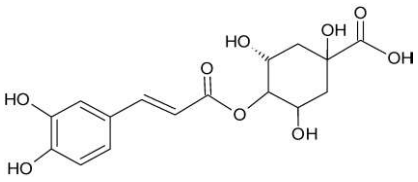

Figure 2B. Structure of crypto-chlorogenic acid.

Alkaloids

Alkaloids are naturally occurring bioactive compounds primarily composed of basic nitrogen, hydrogen, carbon, and oxygen atoms (Figure 3). Several alkaloids, including 1,3-dibenzyl urea and 4-(α-L-rhamnopyranosyloxy), have been isolated from the leaves, seeds, roots, and other parts of the plant. These compounds are known for their ability to scavenge free radicals and provide protection against cardiovascular issues (Abd Rani et al., 2018).

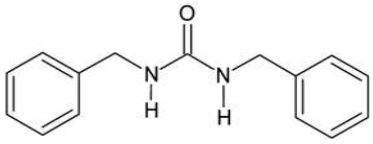

Figure 3. Structure of 1,3-dibenzyl urea.

Vitamins

Moringa oleifera fresh leaves are reported to contain approximately 11,300–23,000 IU of vitamin A. They are also rich in carotenoids with pro-vitamin A and vitamin C, making them an excellent source of these nutrients. Vitamin C plays a crucial role in the synthesis and metabolism of various molecules, including tryptophan, tyrosine, folic acid, and proline, and is involved in the hydroxylation of glycine, proline, lysine, carnitine, and catecholamines. Additionally, it enhances iron absorption in the gut by converting ferric to ferrous state and promotes the conversion of cholesterol into bile acids, thereby reducing blood cholesterol levels (Figure 4A, 4B). As an antioxidant, vitamin C also protects the body from the harmful effects of toxins, pollutants, and free radicals (Leone et al., 2015).

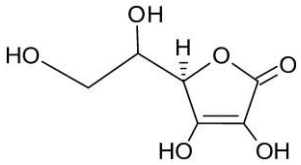

Figure 4A. Structure of L-Ascorbic acid.

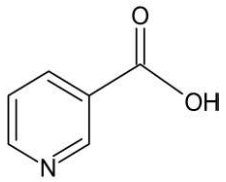

Figure 4B. Structure of Niacin.

Glucosinolates

The concentrations of glucosinolates are influenced by the plant's physiological stage and the maturity of the leaves. In *Moringa oleifera*, the most abundant leaf glucosinolates are identified as 4-O-(α-L-rhamnopyranosyloxy)-benzyl glucosinolate and 4-hydroxybenzyl glucosinolate (Amaglo et al., 2010), as shown in Figure 5.

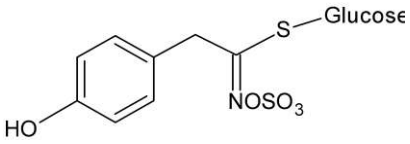

Figure 5. Structure of 4 Hydroxybenzyl glucosinolate (Sinalbin).

Terpenes

Lutein has been identified as the primary terpene in *Moringa oleifera* leaves (Teixeira et al., 2014; Saini et al., 2014), as depicted in Figure 6.

In addition, various other phytochemicals present in this plant are depicted in Figure 8.

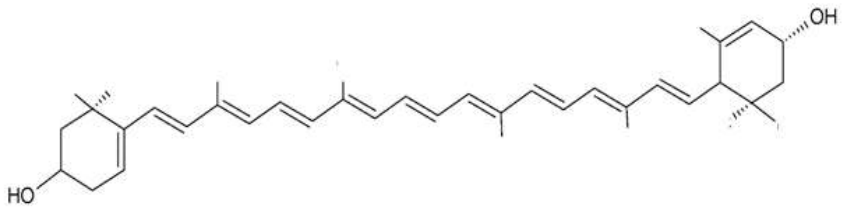

Figure 6. Structure of All-E- Lutein.

Table 1. Different Amino Acids present in *Moringa oleifera* and their use (Abrams et al.,1993; Akram et al., 2011)

Sr. No	Amino acids	Uses in the Human body
1	Ar (Arginine)	Anti-ageing, skin is kept smooth, firm, and plump.
2	His (Histidine)	Use in the biosynthesis of protein
3	Lys (Lysine)	Necessary for human health but the human body cannot make it have to get it in the form of food.
4	Trp (Tryptophan)	Helps in the making of melatonin and serotonin. Serotonin helps to regulate sleep, appetite, mood, and pain.
5	Phe (Phenylalanine)	Helps to regulate the production of many hormones and chemicals. Improve memory, and mood, and decrease anxiety.
6	Met (Methionine)	Antioxidants protect the cell from oxidative stress and help in the growth of new blood vessels.
7	Thr (Theroine)	An essential amino acid, that can be taken by diet only, Boost immune system, important for the formation of collagen, elastin, and tooth enamel
8	Leu (Leucine)	Essential amino acids, regulate protein synthesis, tissue regeneration, metabolism
9	Ile (Isoleucine)	Branched-chain amino acid is necessary as a stress reliever, energy-producing, and important for healthy muscle.
10	Val (Valine)	Promotes muscle growth and tissue repair, enhancing energy.

Moringa leaves contain all essential amino acids, which are fundamental components of proteins (Mahmood et al., 2011). The two most important amino acids present in Moringa leaves are arginine and histidine, which are crucial for young children who cannot synthesize protein adequately for their development and growth. Researchers estimate that 30% of children in sub-Saharan Africa suffer from protein deficiencies, and drumstick leaves can be a significant source of nutrition for these children (Fuglie, 2001; Manzoor, 2007). Other amino acids in Moringa leaves and pods include lysine, tryptophan, phenylalanine, methionine, threonine, leucine, isoleucine, and valine. The amount of amino acids is always higher in dried leaves compared to green leaves and legumes. Moringa leaves (100 grams of dried leaves) contain ten times more carotene than carrots, twelve times more vitamin C than oranges, seventeen times more calcium than milk, double the protein content of cow's milk, and fifteen times more potassium than bananas (Table 1). Additionally, they are an outstanding source of vitamin B and other micronutrients (Razis et al., 2014). Moreover, Moringa contains a variety of unusual sugar-modified glucosinolates, including a group of sugar and rhamnose, which have been discovered in the plant (Amaglo et al., 2010). Reports suggest that these compounds have unique chemopreventive efficacy by triggering apoptosis (Brunelli et al., 2010).

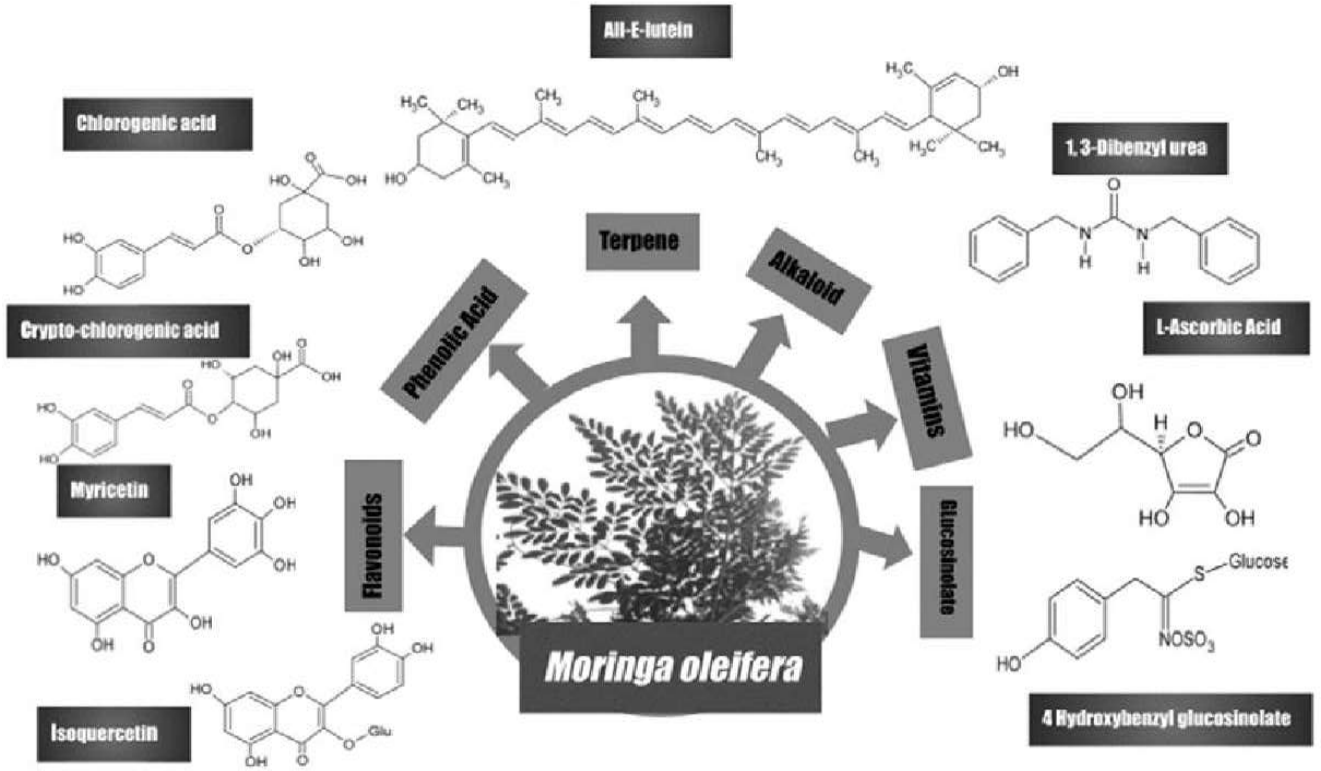

Figure 7. Phytochemical structure of *Moringa oleifera.*

The Application of Moringa Leaves and Seed Extract in Neurodegenerative Disorders

Neurodegeneration is recognized as the key pathophysiological change in most brain-related disorders (Merelli et al., 2013). The onset and progression of neurodegeneration are influenced by specific genes, as well as the timing and extent of the degeneration (Van den Heuvel & Sporns, 2013). While most neurons originate in the brain, they are distributed throughout the body (Pino et al., 2017). Neural stem cells produce the majority of neurons during childhood, but their numbers decrease significantly in adulthood (Ganat et al., 2006). Neurons are perishable, and their gradual loss, along with the deterioration of their structure and function, is known as neurodegeneration (Basics, 2002). Neurodegeneration is linked to synaptic dysfunction, disruption of neural networks, and the accumulation of physically and chemically modified protein variants in the brain (Scott et al., 2010; Kovacs, 2019). Common neurodegenerative diseases include Alzheimer's disease, Parkinson's disease, prion disease, amyotrophic lateral sclerosis, motor neuron disease, Huntington's disease, spinal muscular atrophy, depression, and spinocerebellar ataxia (Klockgether et al., 2019; Lamptey et al., 2022). Recent investigations suggest that *Moringa oleifera* exhibits neuroprotective effects against Alzheimer's disease (AD), dementia, Parkinson's disease (PD), stroke, and neurotoxicity-related issues. Several neuroprotective phytochemicals isolated from *Moringa oleifera,* including quercetin, chlorogenic acid, myricetin, isoquercetin, and cryptochlorogenic acid, have shown efficacy against various brain-related conditions such as AD, PD, ischemia-reperfusion injury (IRI), depression, epilepsy, multiple sclerosis (MS), Huntington's disease, cognitive impairment (CI), and oxidative stress (Ghimire et al., 2021; Hashim et al., 2021) as depicted in Figure 8. According to Bollen and Prickaerts (2012), many neurodegenerative disorders are associated with cyclic nucleotide intracellular signaling, with cyclic nucleotide phosphodiesterases (PDEs) playing a crucial role in this process. Abnormal PDE expression and function, leading to disrupted cyclic nucleotide signaling, may contribute to neurodegenerative disorders. Alterations in the expression of PDE4, PDE7, and PDE8 in the brain may be associated with Alzheimer's disease, while changes in PDE4 and PDE11 expression may contribute to major depressive disorders. Additionally, neurodegenerative disorders such as Huntington's disease and Parkinson's disease are linked to abnormal expression of PDE1B and PDE10. Recent research reveals that

oxidative stress is a primary cause of neurodegenerative disorders. The exceptional antioxidant activity of Moringa species can be attributed to their high phenolic content, which stabilizes free radicals generated in cells (Rani et al., 2018). Extracts from both mature and young *Moringa oleifera* leaves have shown potent antioxidant activity, protecting against oxidative damage (Mahmood, 2010). Raza et al., (2024) observed that PD, a leading neurodegenerative disorder affecting 1 to 3% of the older population, is largely driven by oxidative stress, leading to dopaminergic neuron loss, neuroinflammation, and mitochondrial dysfunction. In their study, they experimented with rotenone-mediated motor function impairments in a PD mouse model. Mice were treated with two types of *Moringa oleifera* seed extract: ethanolic and aqueous. The brains of Parkinson's disease mice were examined, and those treated with Moringa seed extract showed a significant reduction in motor dysfunction compared to the rotenone-treated mice. AD is characterized by cognitive and behavioral deterioration due to cholinergic nervous system dysfunction (Scarpini, 2003). Jhou et al., (2018) investigated the neuropharmacological effects of 70% ethanolic *Moringa oleifera* seed extract (MSE) on cognitive impairment induced by scopolamine injection in mice. Mice were administered 250 or 500 mg/kg of Moringa seed extract orally for 7 or 14 days. The results indicated that Moringa seed extract has anti-amnesic effects and induces cognitive improvement through the enhancement of the cholinergic neurotransmission system and neurogenesis. Additionally, Moringa leaves exhibit nootropic activity and protection against oxidative stress in AD (Mohan, 2005). Ekong et al., (2017) reported that *Moringa oleifera* leaf extract protects against aluminum-induced temporal cortical degeneration in male albino Wistar rats, reducing serum aluminum concentration and combating aluminum-induced neurohistopathology. Another study found that incubating embryonic hippocampal neurons with *Moringa oleifera* leaf extract promoted axodendritic maturation and neuroprotection (Hannan et al., 2014). Furthermore, *Moringa oleifera* has been tested against hyperhomocysteinemia-induced AD-like pathology in rats, showing prevention of oxidative stress and cognitive impairments induced by homocysteine, and reducing tau hyperphosphorylation and Aβ production in the AD rat model (Mahaman et al., 2018; Ahmad et al., 2021). Dementia is a serious neurodegenerative disorder in elderly people characterized by loss of global cognitive ability along with memory impairment, attention deficits, language difficulties, and problem-solving issues. Sutalangka et al., (2013) demonstrated that Moringa leaf extract enhances memory, cholinergic function, and reduces oxidative stress, further improving dopaminergic

function by increasing regional blood flow and suppressing monoamine oxidase (MAO).

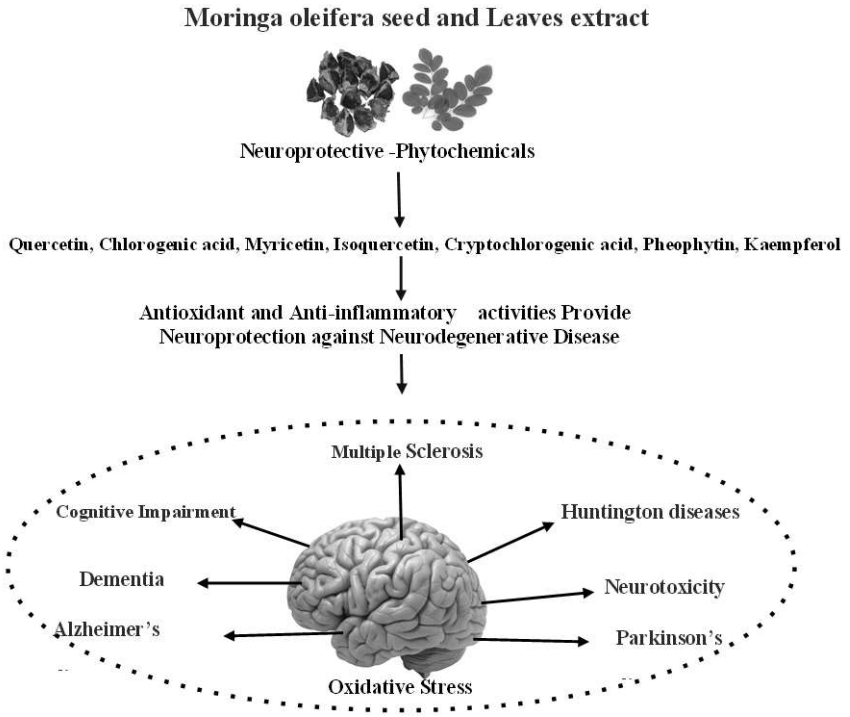

Figure 8. Neuroprotective activity of *M. oleifera* (Ghimire et al., 2021; Hashim et al., 2021).

Conclusion

Moringa oleifera is a highly affordable and reliable source of nutritious food. Its remarkable nutritional value is evident in all parts of the plant, including the leaves, fruit, seeds, and stem, which are beneficial for treating various diseases. Several phytochemicals isolated from *Moringa oleifera* exhibit antioxidant properties, making them promising candidates for applications in neurodegenerative diseases. However, further research is needed to develop preventive strategies against these disorders and to identify specific active ingredients with potential neuroprotective capacities.

Acknowledgments

The author would like to thank Dr. Daljeet Kaur, and Dr. Prabhjot Kaur for their motivation, help and support.

References

Abrams, B., Duncan, D., & Hertz-Picciotto, I. (1993). A prospective study of dietary intake and acquired immune deficiency syndrome in HIV-seropositive homosexual men. *JAIDS Journal of Acquired Immune Deficiency Syndromes*, *6*(8), 949-958.

Ahmad, S. S., Khalid, M., Kamal, M. A., & Younis, K. (2021). Study of Nutraceuticals and Phytochemicals for the Management of Alzheimer's Disease: A Review. *Current Neuropharmacology*, *19*(11), p.1884.

Akram, M., Asif, H. M., Uzair, M., Akhtar, N., Madni, A., Shah, S. A., Hasan, Z. U., & Ullah, A., (2011). Amino acids: A review article. *Journal of medicinal plants research*, *5*(17), pp. 3997-4000.

Amaglo, N. K., Bennet R. N., Curto RBL, et al., (2010). Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. *Journal of Food Chemistry*, 122, 1047-54.

Basics, B. (2002). The life and death of a neuron. *Office of Communications and Public Liaison, National Institute of Neurological Disorders and Stroke: Bethesda, MD, USA*.

Bollen, E., & Prickaerts, J. (2012). Phosphodiesterases in neurodegenerative disorders. *IUBMB life*, *64*(12), 965-970.

Brunelli, D., Tavecchio, M., Falcioni, C., Frapolli, R., Erba, E., Iori, R., Rollin, P., Barillari, J., Manzotti, C., Morazzoni, P., & D'Incalci, M. (2010). The isothiocyanate produced from glucomoringin inhibits NF-kB and reduces myeloma growth in nude mice *in vivo*. *Biochemical Pharmacology*, 79, 1141-1148.

Chambial, S., Dwivedi, S., Shukla, K. K., John, P. J., & Sharma, P. (2013). Vitamin C in disease prevention and cure: An overview. *Indian Journal of Clinical Biochemistry*, 2013, 28, 314–328.

Dhakad, A. K., Ikram, M., Sharma, S., Khan, S., Pandey, V. V., & Singh, A. (2019). Biological, nutritional, and therapeutic significance of *Moringa oleifera* Lam. *Phytotherapy Research*, *33*(11), 2870-2903.

Ekong, M. B., Ekpo, M. M., Akpanyung, E. O., & Nwaokonko, D. U. (2017). Neuroprotective effect of *Moringa oleifera* leaf extract on aluminium-induced temporal cortical degeneration. *Metabolic Brain Disease*, *32*, 1437-1447.

El-Saadony, M. T., Zabermawi, N. M., Burollus, M. A., Shafi, M. E., Alagawany, M., Yehia, N., Askar, A. M., Alsafy, S. A., Noreldin, A. E., & Khafaga, A. F. (2023). Nutritional aspects and health benefits of bioactive plant compounds against infectious diseases: A review. *Food Reviews International*, 39(4), 2138-216.

Foidl N., Makkar H. P. S., & Becker K. (2001). The potential of *Moringa oleifera* for agricultural and industrial uses, 2001. *Dar Es Salaam.*

Fuglie, L. J. (2001) The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the Tropics. *Training Manual. 2001*. Church World Service, Dakar, Senegal.

Ganat, Y. M., Silbereis, J., Cave, C., Ngu, H., Anderson, G. M., Ohkubo, Y., Ment, L. R., & Vaccarino, F. M. (2006). Early postnatal astroglial cells produce multilineage precursors and neural stem cells *in vivo*. *Journal of Neuroscience*, *26*(33), 8609-8621.

Ghimire, S., Subedi, L., Acharya, N., & Gaire, B. P. (2021). Moringa oleifera: A tree of life as a promising medicinal plant for neurodegenerative diseases. *Journal of Agricultural and Food Chemistry*, *69*(48), 14358-14371.

Hannan, M. A., Kang, J. Y., Mohibbullah, M., Hong, Y. K., Lee, H., Choi, J. S., Choi, I. S., & Moon, I. S. (2014). *Moringa oleifera* with promising neuronal survival and neurite outgrowth promoting potentials. *Journal of Ethnopharmacology*, 152(1), 142-150.

Hashim, J. F., Vichitphan, S., Boonsiri, P., & Vichitphan, K. (2021). Neuroprotective assessment of *Moringa oleifera* leaves extract against oxidative-stress-induced cytotoxicity in SHSY5Y neuroblastoma cells. *Plants*, *10*(5), 889.

Klockgether, T., Mariotti, C., & Paulson, H. L. (2019). Spinocerebellar ataxia. *Nature Reviews Disease Primers*, *5*(1), 24.

Kovacs, G. G. (2019). Molecular pathology of neurodegenerative diseases: principles and practice. *Journal of Clinical Pathology*, *72*(11), 725-735.

Lamptey, R. N., Chaulagain, B., Trivedi, R., Gothwal, A., Layek, B., & Singh, J. (2022). A review of the common neurodegenerative disorders: current therapeutic approaches and the potential role of nanotherapeutics. *International Journal of Molecular Sciences*, *23*(3), 1851.

Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J., & Bertoli, S. (2015). Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of *Moringa oleifera* leaves: An overview. *International Journal of Molecular Sciences*, 16(6), 12791-12835.

Mahaman, Y. A. R., Huang, F., Wu, M., Wang, Y., Wei, Z., Bao, J., Salissou, M. T. M., Ke, D., Wang, Q., Liu, R., Wang, J. Z., Zhang, B., Chen, D., & Wang, X. (2018). *Moringa oleifera* alleviates homocysteine-induced Alzheimer's disease-like pathology and cognitive impairments. *Journal of Alzheimer's Disease*, *63*(3), 1141-1159.

Mahmood, K. T., Mugal, T., & Haq, I. U. (2010). Moringa oleifera: a natural gift-A review. *Journal of Pharmaceutical Sciences and Research*, *2*(11), 775.

Manzoor, M., Anwar, F., Iqbal, T., & Bhanger, M. I. (2007). Physico-chemical characterization of Moringa concanensis seeds and seed oil. *Journal of the American Oil Chemists' Society*, *84*, 413-419.

Merelli, A., Czornyj, L., & Lazarowski, A. (2013). Erythropoietin: a neuroprotective agent in cerebral hypoxia, neurodegeneration, and epilepsy. *Current Pharmaceutical Design*, *19*(38), 6791-6801.

Mohan, M., Kaul, N., Punekar, A., Girnar, R., Junnare, P., & Patil, L. (2005). Nootropic activity of *Moringa oleifera* leaves. *Journal of Natural Remedies*, *5*(1), 59-62.

Morton, J. F. (1991). The Horseradish Tree, Moringa pterygosperma (Moringaceae) - A Boon to Arid Lands? *Economic Botany,* 45, 318-333.

Nigam, V., & Sodhi, J. S. (2014). Some medicinal plants with antioxidant activity: a review. *International Journal of Pharmacy and Biological Sciences*, *4*, 173-8.

Pino, A., Fumagalli, G., Bifari, F., & Decimo, I. (2017). New neurons in adult brain: distribution, molecular mechanisms and therapies. *Biochemical Pharmacology*, *141*, 4-22.

Popoola, J. O., & Obembe, O. O. (2013). Local knowledge, use pattern and geographical distribution of *Moringa oleifera* Lam. (Moringaceae) in Nigeria. *Journal of Ethnopharmacology*, 150, 682–691.

Raja, R. R., Sreenivasulu, M., Vaishnavi, S., Muni Navyasri, D., Samatha, G., & Geethalakshmi, S. (2016). Moringa oleifera: An overview. *RA Journal of Applied Research*, 2(9), 620-624.

Rani, N. Z., Husain, K., & Kumolosasi, E. (2018). Moringa genus: a review of phytochemistry and pharmacology. *Frontiers in pharmacology*, *9*, 108.

Raza, C., Mohsin, S., Faheem, M., Hanif, U., Alkhathlan, H. Z., Shaik, M. R., Riaz, H. A., Anjum, R., Jurrat, H., & Khan, M. (2024). *In Vivo* Study of *Moringa oleifera* Seed Extracts as Potential Sources of Neuroprotection against Rotenone-Induced Neurotoxicity. *Plants*, *13*(11), 1479.

Razis, A. F., Ibrahim, M. D., & Kntayya, S. B. (2014). Health benefits of Moringa oleifera. *Asian pacific journal of cancer prevention*, *15*(20), 8571-8576.

Saini, R. K., Shetty, N. P., & Giridhar, P. (2014). Carotenoid content in vegetative and reproductive parts of commercially grown *Moringa oleifera* Lam. cultivars from India by LC–APCI–MS. *European Food Research and Technology*, 238(7), 971–978.

Scarpini, E., Scheltens, P., & Feldman, H. (2003). Treatment of Alzheimer's disease: current status and new perspectives. Lancet Neurology, 2, 539–547.

Scott, D. A., Tabarean, I., Tang, Y., Cartier, A., Masliah, E., & Roy, S. (2010). A pathologic cascade leading to synaptic dysfunction in α-synuclein-induced neurodegeneration. *Journal of Neuroscience*, *30*(24), 8083-8095.

Sharma, V., Paliwal, R., Janmeda, P., & Sharma, S. (2012). Renoprotective effects of *Moringa oleifera* pods in 7,12-dimethylbenz[a]anthracene-exposed mice. *Journal of Chinese Integrative Medicine*, 10, 1171–1178.

Singh, G. P., & Sharma, S. K. (2012). Antimicrobial evaluation of leaf extract of *Moringa oleifera* Lam. *International Research Journal of Pharmacy*, 3, 1–4.

Sutalangka, C., Wattanathorn, J., Muchimapura, S., & Thukham-mee, W. (2013). *Moringa oleifera* mitigates memory impairment and neurodegeneration in animal model of age-related dementia. *Oxidative Medicine and Cellular Longevity*, *2013*(1), 695936.

Teixeira, E. M., Carvalho, M. R., Neves, V. A., Silva, M. A., & Arantes-Pereira, L. (2014). Chemical characteristics and fractionation of proteins from *Moringa oleifera* Lam. leaves. *Food Chemistry*, 147, 51–54.

Van den Heuvel, M. P., & Sporns, O. (2013). Network hubs in the human brain. *Trends in Cognitive Sciences*, *17*(12), 683-696.

Vongsak, B., Sithisam, P., & Gritsanapan, W. (2014). Simultaneous HPLC quantitative analysis of active compounds in leaves of *Moringa oleifera* Lam. *Journal of Chromatographic Science*, 52(6), 641–645.

Yabesh, J. E., Prabhu, S., & Vijayakumar, S. (2014). An ethnobotanical study of medicinal plants used by traditional healers in silent valley of Kerala, India. *Journal of Ethnopharmacology*, 154, 774–789.

Zaffer, M., Ahmad, S., Sharma, R., Mahajan, S., Gupta, A., & Agnihotri, R. K. (2014). Antibacterial activity of bark extracts of *Moringa oleifera* Lam. Against some selected bacteria. *Pakistan Journal of Pharmaceutical Sciences*, 27, 1857–1862.

Zhou, J., Yang, W. S., Suo, D. Q., Li, Y., Peng, L., Xu, L. X., Zeng, K. Y., Ren, T., Wang, Y., Zhou, Y., & Zhao, Y. (2018). *Moringa oleifera* seed extract alleviates scopolamine-induced learning and memory impairment in mice. *Frontiers in Pharmacology*, *9*, 389.